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(71) Applicant(s)
Sagem SA
(Incorporated in France)
6 Avenue d'Iena, 75116 Paris, France

(72) Inventor(s)
Fernando Romao

(74) Agent and/or Address for Service
Fitzpatricks
39 Stukeley Street, LONDON, WC2B 5LT,
United Kingdom

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(54) Abstract Title

Device for the production of a phase-modulated and amplitude-modulated signal

(57) Device (102) for the production of phase-modulated and amplitude-modulated signals working on the basis of I and Q input signals (129, 130) has a saturator circuit (106) between a modulator circuit (103) and a phase-locked loop circuit (109). The phase-locked loop (109) produces a modulated signal of constant amplitude that is amplified by a power amplifier (112). The amplification is modulated by a signal produced from signals picked up between the modulator (103) and the saturator (106), and after the amplifier (113). These picked-up signals are used by a comparator circuit (120) to produce the amplitude modulation command. These signals are detected by detectors (117, 127) having similar transfer functions.

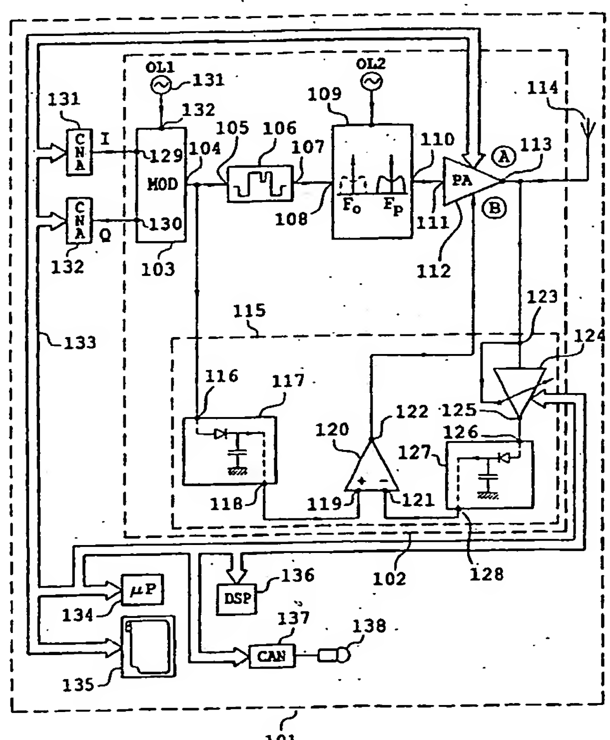

Fig. 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

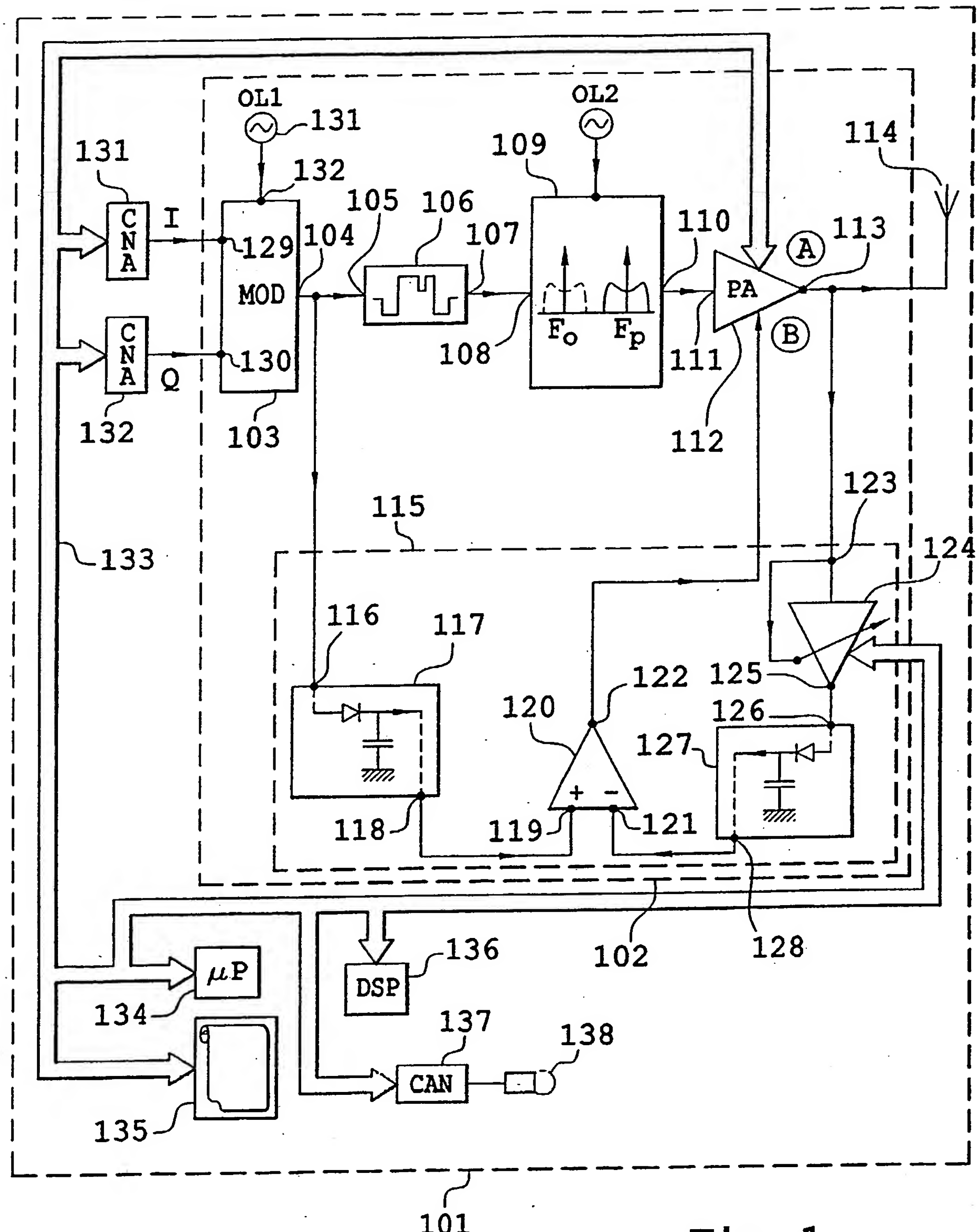
OL1
131
131
132
C N A
I
129
MOD
130
C N A
Q
132
103
104
105
106
107
108
109
OL2
F_o
F_p
110
111
112
PA
A
B
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
133
102
μP
134
135
DSP
136
CAN
137
138
101

Fig. 1

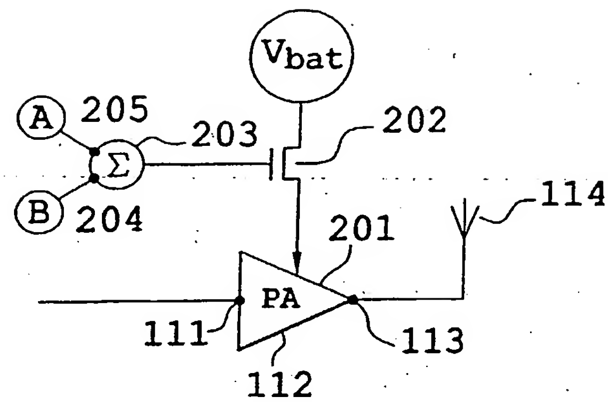
Vbat
A
B
Σ
205
203
202
204
201
114
PA
111
113
112

Fig. 2

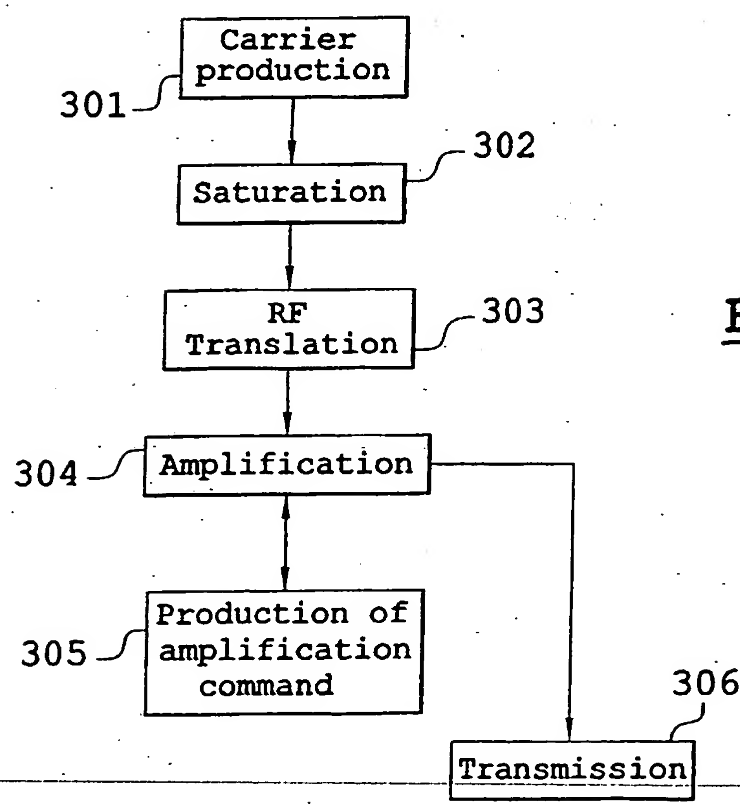
Carrier production
301
Saturation
302
RF Translation
303
Amplification
304
Production of amplification command
305
306
Transmission

Fig. 3

Device for the production of a phase-modulated and amplitude-modulated of a signal and method for the production of such a signal

The object of the invention is a device for the production of a phase-modulated and amplitude-modulated RF signal and a method for the production of such a signal. The field of the invention is that of phase-modulated, variable envelope RF signals. In particular, the field of the invention therefore is that of mobile telephony. However, the invention can be applied in other fields where the production of such phase-modulated and amplitude-modulated signals is implemented. The aim of the invention is to be able to make a device producing phase-modulated and amplitude-modulated signals in minimizing the impact of the complexity of the signal produced on the cost of the apparatus. The aim of the invention therefore is also to make an apparatus of this kind by using ordinary components and circuits.

In the prior art, there are known mobile telephones that produce phase-modulated and amplitude-modulated signals of this kind. These mobile telephones work according to the UMTS, EDGE or other standards. These standards use a CDMA-type modulation. The device implemented by these apparatuses comprises a digital stage to produce modulating signals, a modulation analog stage and a power stage, namely a stage of amplification before transmission.

In the prior art, the digital stage produces three signals. First and second I and Q signals are phase-modulating signals. These I and Q signals are inputs of the modulating stage. These two signals I and Q are sent on a first cosine input of a first mixer and a first sine input of a second mixer respectively. A second cosine input of the second mixer is connected to an output of an oscillator, which is generally sinusoidal. A second sine input of the second mixer is connected to the output of the oscillator by means of a 90° phase-shifter circuit. This phase-shifter circuit has a function of producing a signal in quadrature as compared with the output signal of the oscillator. The first mixer and the second mixer each comprise an output connected to a first input and a second input of an adder device respectively. At output of this adder device, a phase-modulated signal with two quadrature components is obtained. The mixers, the phase-shifter circuit and the adder

device form a conventional modulator. The signal obtained at output of the modulator is used as an input of the power stage.

The modulation stage also comprises a frequency translation device or phase control device. This translation device is used to translate the modulated signal into a frequency band in which it must be sent.

The digital stage produces a third amplitude-modulating signal AM. This signal is used to control the gain of the power stage. In the prior art, to obtain an accurate gain control, the power command is compared with the output of the power stage. This comparison is done through a comparator. Between the output of the power stage and the comparator, a detector is placed. Indeed, the output of the power stage is a modulated signal while the comparator needs a level. The detector is therefore used to give the output level of the power stage. This output level is then compared with an amplitude-modulating signal which gives a control signal of the power stage. A particular feature of this device is that the detector has to be linear and highly precise. This is especially difficult to obtain as this detector works at high frequencies of about 1 GHz. The cost of this detector is therefore great. This is all the more inconvenient as most present-day telephones are two-band or even three-band telephones. This means that there will be as many amplification stages as there are frequencies at which the telephone is capable of transmitting. This situation thus greatly increases the number of detectors in the mobile telephone and considerably raises its cost of manufacture.

Another problem of the prior art is that the digital stage must produce three modulating signals. This therefore increases the load of the microprocessor-type logic circuits linked to the production of these modulating signals. Furthermore, this complicates the interface between the digital stage and the modulation stage.

The invention resolves these problems by the use of a digital stage that produces only two phase-modulating and amplitude-modulating I and Q signals, these two signals being the input of a modulator stage. These two signals are used in a modulator circuit working at an intermediate frequency. The output of these modulator circuits is a phase-modulated and amplitude-modulated signal comprising two components in quadrature. This quadrature signal is therefore used as an input of a limiter stage. This stage in practice

is used to saturate the quadrature signal. The output of this limiter circuit is used as the input of a phase-locked loop circuit whose output is the input of a power stage. A signal is picked up at the input of the limiter circuit and at the output of the power stage. These two picked-up signals serve as inputs for a comparator whose output controls the power stage. The two picked-up signals are respectively subjected to detectors. The particular feature of these detectors is that they can be of an ordinary type. For example a simple envelope detector, even a non-linear one, is enough. It is enough for these detectors to be of the same nature. Since the signal at output of the amplification stage is amplified, a circuit for the automatic control of this level can be placed between this output and the input of the detector, so that the mean levels of the signals driving the two detectors will be identical. This further facilitates the designing of the detectors.

In one variant of the invention, the power stage and the automatic level control circuit are also controlled by a circuit coming from the logic stage. This is useful when the device has to produce signals corresponding to different power ranges. The signal coming from the logic stage is then used to control the power range.

An object of the invention is a device for the production of a phase-modulated and amplitude-modulated RF signal comprising the following cascade-connected elements: a modulation circuit connected to a phase-locked loop circuit, connected to a power amplifier circuit, wherein the device comprises, between the modulation circuit and the phase-locked loop circuit, a circuit to produce a signal of constant amplitude in accordance with the phase modulation, and wherein the signal-production device comprises control circuits to control the amplifier circuit, the control circuits having, at input, a signal picked up at output of the modulation circuit and a signal picked up at output of the amplifier circuit.

An object of the invention is also a method for the production of a phase-modulated and amplitude-modulated RF signal wherein:

- a phase-modulated and amplitude-modulated carrier signal is produced from two I and Q signals in quadrature,

- the modulated carrier is saturated to obtain a phase-modulated saturated signal,

- the saturated signal is translated at the transmission frequency to

obtain a translated signal,

- the translated signal is amplified to obtain an amplified signal,

- the amplification is controlled by a control signal produced from the comparison of the modulated carrier and the amplified signal, the level of said amplified signal being brought to a level compatible with the level of the modulated carrier.

The invention will be understood more clearly from the following description and the appended figures. These figures are given by way of an indication and in no way restrict the scope of the invention. Of these figures:

- Figure 1 illustrates means useful for the implementation of the device according to the invention;

- Figure 2 illustrates exemplary commands of the power stage;

- Figure 3 illustrates a step of the method according to the invention.

Figure 1 shows an apparatus 101 comprising a device 102 according to the invention. In the exemplary description, it is assumed that the apparatus 101 is a mobile telephone. The device 102 has a modulation circuit 103. An output 104 of the modulator 103 is connected to an input 105 of a limiter circuit 106. An output 107 of the limiter circuit 106 is connected to an input 108 of a phased-locked loop circuit 109. An output 110 of the phase-locked loop circuit 109 is connected to an input 111 of a power amplifier circuit 112. An output 113 of the amplifier circuit 112 is connected to an antenna 114.

Figure 1 also shows control circuits 115. The circuit 115 has a first input 116 connected to the output 104 of the modulator 103. The input 116 of the circuits 115 corresponds to the input of a detector circuit 117. An output 118 of the detector circuit 117 is connected to an input 119 of a comparator circuit 120. The comparator circuit 120 has a second input 121 and an output 122. The comparator circuit 120 is for example a differential amplifier. In other words, it is an amplifier that measures a difference of levels between signals present at its inputs 119 and 121, and amplifies this difference to produce a signal at its output 122. The output 122 of the comparator 120 is a control signal of the power amplifier 112.

The circuit 115 has a second input 123. The input 123 is connected to the output 113 of the power amplifier 112. The input 123 of the circuits 115 corresponds to an input of an automatic level control circuit 124. In practice,

the circuit 124 is a variable gain attenuator. The function of the circuit 124 is to ensure that the signal at the output 125 of the circuit 124 always has a constant mean level, whatever the level of the signal at the input 123. This mean level is comparable to the mean level of the signal present at the input 116. This is why the signal present at the input 123 is also used as a control signal for the circuit 124. The output 125 of the circuit 124 is connected to an input 126 of a detector circuit 127. An output 128 of the circuit 127 is connected to the input 121 of the comparator circuit 120.

Figure 1 shows that the modulator circuit 103 has two inputs 129 and 130. Furthermore, the circuit 103 is also connected to a local oscillator 131 by an input 132. The circuit 103 is for example of the type described in the introduction to the description. It is then assumed that the input 129 corresponds to the first cosine input and that the input 130 corresponds to the first sine input. The input 132 is then connected to the first mixer through a second cosine input and a second mixer through a second sine input and a 90° phase-shifter. The output of the adder device then corresponds to the output 104.

The circuit 106 may for example be an amplifier working in saturation mode. The signal at the input of the circuit 106 is of the $\alpha(t)\cos(\omega_0(t) + \varphi)$ type. The signal at the output of the circuit 106 becomes $A \cos(\omega(t) + \varphi)$, with A as a constant. Therefore, at output of the circuit 106, there is in fact a signal with constant amplitude and variable phase.

The phase-locked loop circuit 109 may for example be a phase-copying looped circuit. At the output of the circuit 109, we therefore have a signal with the form $B \cos(\omega_{TX}(t) + \varphi)$.

The inputs 129 and 130 are respectively supplied with the I and Q signals which themselves come respectively from a first digital-analog converter 131 and a second digital-analog converter 132. The converters 131 and 132 are connected to a bus 133. In the description, the term "bus" designates a set of wires and tracks comprising a sufficient number of these elements to convey signals of addresses, data, clocks, interruptions, commands and supply. Said supply is not shown in Figure 1.

The telephone 101 also has a microprocessor 134, a program memory 135, a signal processor 136, an analog-digital converter 137 connected to a microphone 138. The elements 134 to 137 are connected to

the bus 133. The microprocessor is controlled by instruction codes recorded in the memory 135. When the user of the telephone 102 speaks, the voice analog signals are produced by the microphone 138 and converted into voice digital signals by the converter 137. These voice digital signals are then sent to the DSP 136 either directly or through the microprocessor 134. The DSP 136, controlled by the memory instruction codes 135, produces digital signals that it sends to the converters 131 and 132. These converters are then capable of producing the I and Q signals which will be the modulating signals used by the circuits 102. The I and Q signals thus produced are phase-modulating and amplitude-modulating signals.

Figure 1 also shows that the power amplifier circuit 112 and the automatic gain circuit 124 are themselves also connected to the bus 133. This arises out of a specific quality of mobile telephony standards. Indeed, the transmission power of a mobile telephone is a function of its visibility to a base station. The base station may request a mobile telephone to make transmission in a power range of variable strength. In practice, mobile telephones can make transmission in a certain range of power. For the GSM standard, this range is divided into twenty zones numbered PO to PI 9. This information is obtained by the mobile telephone during a communication with the mobile telephony network to which it is connected. Figure 2 illustrates the means to take account of the two control information elements for the power amplifier 112. Figure 2 shows the amplifier 112 receiving a control signal through a control input 201. It is assumed here that the amplifier 112 works in saturation mode and that the input 201 actually corresponds to its power supply voltage. By varying the power supply voltage, we thus modulate the output level of the amplifier 112. This output level then follows the power voltage. The control input 201 is connected to the power supply voltage through a transistor 202. The gate of the transistor 202 is connected to an adder device 203. The device 203 has two inputs, namely a first input 204 for a signal B coming from the comparator 120 and a second input 205 for a control signal A coming from the microprocessor 134. Thus, the power supply voltage of the amplifier 112 is regulated as a function of both the power range and the amplitude modulation.

In the example of Figure 1, the detectors 117 and 127 are of the same nature. Furthermore, the levels at their inputs are comparable. The detectors

117 and 127 therefore have identical transfer functions. The detector 117 for example, at input, has a diode connected to a capacitor itself connected to a ground. The output of the diode also forms the output 118 of the detector 117. The detector 117 herein is actually an envelope detector. A detector 127 has similar elements. This means that the transfer function of the detectors 117 and 127, output = f(input), is the same. It is then appropriate to compare the output of the detectors 117 and 127. Furthermore, as a result of this characteristic, the detectors 117 and 127 may be non-linear and not very precise.

In one variant of the invention, the detectors 117 and 127 work at the same frequency. This means that for example there is a device to bring the frequency of the output signal of the amplifier 112 to the frequency of the signal present at the output 104. This device is for example a subtractor whose first input is the signal of the output 113 and whose second input is a signal delivered by a quartz crystal. The signal of this quartz crystal is at the frequency at which it is desired to subtract the signal delivered by the amplifier 112. It is also possible to increase the frequency of the input signal 116.

Figure 3 illustrates steps of the method according to the invention. The method of the invention has already been described in the description of the device. Indeed, the device implements this method. We shall limit the description here to recalling its main steps. Figure 3 shows a preliminary step 301 for the production of a phase-modulated and amplitude-modulated carrier. This carrier is produced from phase-modulating and amplitude-modulating I and Q signals.

From the step 301 there is a passage to a step 302 of saturation of the modulated carrier. This saturation is performed by the circuit 106. The aim of this saturation is to obtain a signal that no longer has anything other than a piece of phase information. There is then a passage to a step 303 of translation into a radio frequency.

In the step 303, the phase-modulated signal coming from the circuit 106 is translated at the frequency at which it has to be sent. There is a passage to an amplification step 304. In the step 304, the translated signal is amplified to the power at which it has to be transmitted. To do this, an amplification command is needed. This command is produced in the step

305 which is carried out simultaneously and permanently at the same time as the step 304.

In the step 305, the amplitude-modulated information is combined with information on the power zone at which the signal has to be sent. The combination of this information produces a control signal for amplification. The amplitude-modulation information is obtained by comparing the level of the phase-modulated and amplitude-modulated carrier with the level of the translated and amplified signal. Before the level of the translated and amplified signal is measured, it is brought to a mean level compatible with that of the modulated carrier. From the step 304 there is then a passage to a step 305 of transmission. This step 305 is that of the simple broadcasting of the amplified signal by the antenna 114.

CLAIMS

1. Device (102) for the production of a phase-modulated and amplitude-modulated RF signal comprising the following cascade-connected elements: a modulation circuit (103) connected to a phase-locked loop circuit (109), connected to a power amplifier circuit (112), characterised in that the device comprises, between the modulation circuit and the phase-locked loop circuit, a circuit (106) to produce a signal of constant amplitude in accordance with the phase modulation, and in that the device comprises control circuits (115) to control the amplifier circuit, the control circuits having, at input, a signal picked up at output (104) of the modulation circuit and a signal picked up at output (113) of the amplifier circuit.

2. Device according to claim 1, characterised in that the circuit used to produce a signal of constant amplitude comprises an amplifier working in saturation mode.

3. Device according to one of the claims 1 or 2, characterised in that the control circuits comprise a comparator (120) whose output controls the power circuits, a first input of the comparator is connected to the output of the modulation circuits through a first detector (117) , a second input of the comparator is connected to the output of the amplifier circuit through a second detector (127).

4. Device according to claim 3, characterised in that the second detector is connected to the output of the amplifier circuit through an automatic level control circuit (124).

5. Device according to claim 4, characterised in that the automatic level control circuit is controlled by a control logic (133, 134, 135) as a function of the level of power at which the RF signal has to be produced.

6. A device according to one of the claims 3 to 5, characterised in that the first and second detectors have identical transfer functions.

7. A device according to one of the claims 3 to 6, characterised in that the first and second detectors work at the same frequency.

8. A device according to one of the claims 1 to 6, characterised in that the amplifier circuit is controlled by a control logic (133-135) as a function of a level of power at which the device must make transmission.

9. A method for the production of a phase-modulated and amplitude-modulated RF signal characterised in that:

- a phase-modulated and amplitude-modulated carrier signal is produced (301) from two I and Q signals in quadrature,

- the modulated carrier (302) is saturated to obtain a phase-modulated saturated signal,

- the saturated signal (303) is translated at the transmission frequency to obtain a translated signal,

- the translated signal (304) is amplified to obtain an amplified signal,

- the amplification is controlled (305) by a control signal produced from the comparison of the modulated carrier and the amplified signal, the level of said amplified signal being brought to a level compatible with the level of the modulated carrier.

10. A method according to claim 9, characterised in that the amplification is controlled (305) as a function of the power level at which the RF signal has to be produced.

11. A device substantially as hereinbefore described with reference to the accompanying drawings.

12. . A method substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

INVESTOR IN PEOPLE

Application No: GB 0114505.1
Claims searched: 1 to 12

Examiner: John Donaldson
Date of search: 24 July 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): H3R(RAMX, RFMA)

Int Cl (Ed.7): H03C 5/00, 5/02, 5/04, 5/06

Other: Online:WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	WO 00/30245 A1 (ERICSSON), see abstract	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.